DOCUMENT RESUME

ED 154 995 SE 024 183

AUTHOR Pederson, Clara A., Ed.
TITLE Insights: Into Open Education, Volume 10, Number 1, September 1977.
INSTITUTION North Dakota Univ., Grand Forks. Center for Teaching and Learning.
PUB DATE Sep 77
NOTE 14p.; Not available in hard copy due to marginal legibility of original document
AVAILABLE FROM Insights, Center for Teaching and Learning, Corwin Hall, University of North Dakota, Grand Forks, North Dakota 58202 (annual subscription $3.50)

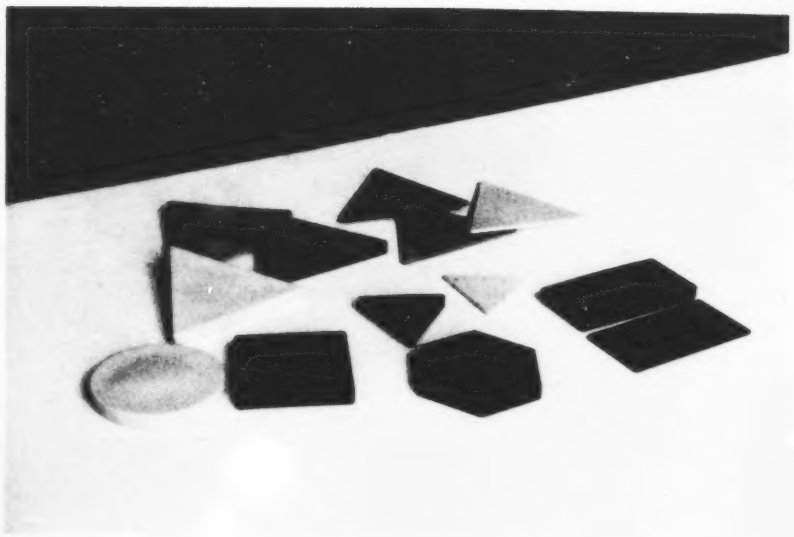
EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Activity Units; Educational Games; *Elementary Education; Elementary School Mathematics; *Instructional Materials; Logic; *Logical Thinking; Manipulative Materials; *Mathematics Education; Resource Materials

ABSTRACT

This newsletter, published eight times during the academic year, is intended for elementary teachers interested in open education. The newsletter includes descriptions of actual classroom projects, discussions of teaching techniques, and sources of curriculum and instructional materials. This issue contains a description of several sets of logic materials and a sequenced series of activities for use with the materials. A rationale for this use is given at the end of the article. (MN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED154995



CENTER FOR TEACHING AND LEARNING
UNIVERSITY OF NORTH DAKOTA
GRAND FORKS 58201

Volume 10, Number 1

September 1977

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Clara Pederson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER

Logic Materials and Activities:

Games for Thought

by Ron Kutz

Introducing the Author

SE 024 183

INSIGHTS into open education

Logic Materials and Activities:

Games for Thought

by Ron Kutz

INTRODUCTION

Through old math, new math, drill, tell and discover, one thing has remained constant. Reasoning and logical abilities have proved to be among the most elusive and difficult to teach. Problem solving, even the most simple of the "word problem" type, have left children confused and teachers in despair. How can we enable children to analyze a problem, plan and carry out a solution, and then evaluate the solution? Among the most promising approaches has been the development of various logic materials and activities.

This article contains a description of several sets of logic materials and a sequenced series of activities for use with the materials. A rationale for this use is given at the end of the article, on the assumption that it will make more sense once the materials and activities are explained to the reader.

Materials for logic activities are readily available for purchase and/or easy to make. They will be described in detail in the next section, with sources listed in Appendix II. Activities are harder to find. Several sources are available and are listed in Appendix I, but they tend to cover only beginning activities. Most of the more advanced activities exist only in the head and notes of Zoltan P. Dienes. The author has had the opportunity this past year to work with Dr. Dienes, and wishes to acknowledge him as the source of several of the activities used in this article.

The activities are sequenced roughly in the order they can be used with children. The starting point and sequence would be the same at any grade from first through college; the time spent and number of activities at each level will of course be greater with the younger children. The final activities listed are challenging to college students (and professors). Do not, however, let this lead you to believe they are impossible for children. They are difficult for adults not because of inherent difficulty, but because they are different from the tasks we normally encounter. Our accumulated knowledge is of little use for some of these, so the child is at no disadvantage in working the problem. Indeed, children may have an advantage since they are used to encountering new situations.

The Logic Materials

The most familiar logic materials are the A - Blocks and People Pieces from the ESS Attribute Games and Materials set (McGraw - Hill, Elementary Science Study). They are representative of all logic materials, in that they have a set of attributes and a set of values for each attribute, from which the pieces are constructed consisting of every possible combination of values. Specifically, the A - blocks have 3 attributes, shape, color and size, with 4 values for shape (circle, square, triangle, diamond), 4 values for color (red, blue, green, yellow) and two values for size (large, small). The set consists of 32 pieces, no two alike, with every possible combination of size, shape and color (a large red diamond, a small yellow circle, etc.). The people pieces have 16 pieces; 4 attributes (age, sex, girth, color) with two values for each.

Also available commercially are attribute logic blocks, which have 60 pieces (5 shapes, 3 colors, 2 sizes, 2 thicknesses), and logic people (2 ages, 2 sexes, 3 positions [running, standing, walking], 4 colors, for 48 pieces). The reader may have noticed that the number of pieces is determined by multiplying the numbers of values for each attribute.

The logic blocks and logic people are somewhat more useful than the A - blocks or people pieces in that they have more attributes than the A - blocks and more

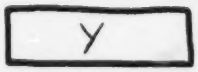
values than the people pieces. Activities frequently call for a smaller set, and can be specified by the number of attributes and values. For example, a 3 x 2 x 2 x 2 set (read 3 by 2 by 2 by 2) requires 4 attributes, with 3 values for one attribute and 2 values for the others. This could be made from the logic blocks by taking all pieces of 3 colors, 2 shapes, 2 sizes and 2 thicknesses, or it could be made by taking 3 shapes, 2 colors, 2 sizes and 2 thicknesses. This set cannot be made with A - blocks or people pieces. A section on making logic materials is at the end of the article.

Notation:

For ease in drawing, the article will use the logic blocks in all examples. The shape will be drawn large or small, the color (red, yellow, blue) will be shown by a letter, and thickness will be symbolized by a heavy right edge. The color letter will be capital in large pieces, lower case in small pieces. Examples:

large thick red triangle

small thick blue circle



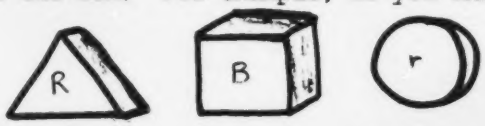
large thin yellow rectangle

The activities, although stated in terms of logic blocks, can all be easily modified for use with any of the other sets of materials.

Beginning Activities

Initial activities should encourage the children to name, classify and organize the materials, and enable them to count differences between pieces. If the children have not worked with the set previously, a good group introduction is:

Activity 1 - From a box or bag, the teacher removes 2 - 4 pieces, shows them to the group, and asks what other pieces might be in the box. For example, if you show

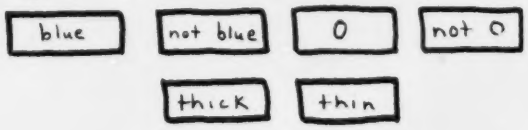


they may guess

etc.

With the set shown, all the thick red and blue pieces will probably be found, and they may or may not guess yellow. You may have to show a yellow piece and then a thin piece to get the whole set.

Sorting activities follow, using strings, hoops or large grids as aids. Tagboard labels may be helpful. For example

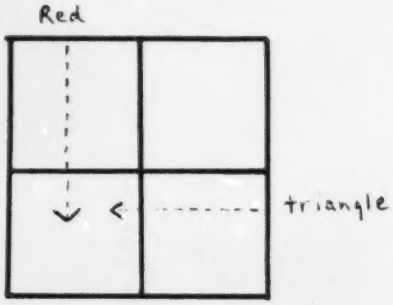


Activity 2 - Put all the triangles in one hoop, circles in another.

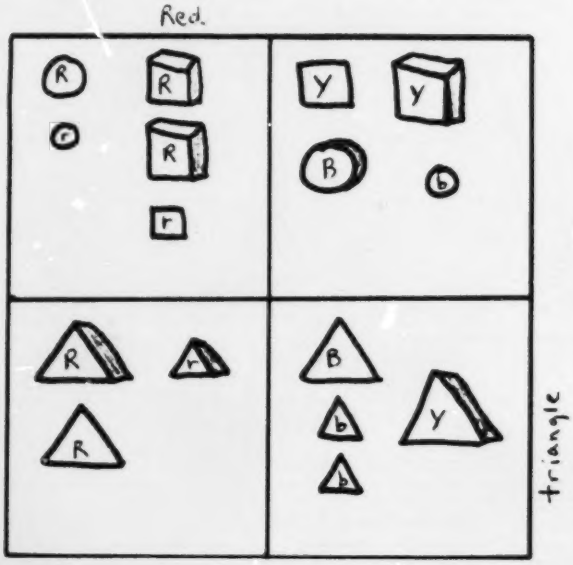
Activity 3 - Put all the triangles in one hoop, red pieces in another.

Activity 3, of course, requires an overlap, since some triangles are red. Have the children name the four sets formed. In activity 3, we will have sets of non-red triangles, red triangles, red non-triangles and non-red non-triangles. We could, of course, label the latter set the blue and yellow circles, squares, rectangles and hexagons, but the use of the negative is both more efficient and leads to insights about the sets being formed. In the place of hoops (which make the now

well known Venn diagram), we could label a Carroll diagram as shown



which, partly filled in, would give

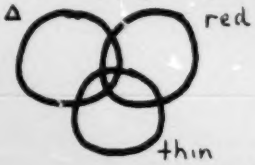


and form the same 4 subsets as in activity three. These problems can be made more complex by

---

Activity 4 - Put all triangles in one hoop, red in another, and thin in a third hoop.

To cover all possibilities, the children must now arrange the hoops like this:



You should, of course, let them find this out for themselves by pointing out when, for example, they have a thick red triangle, it must be in exactly two of the three hoops.

Similar activities should continue until the children are thoroughly familiar with the pieces and can quickly name their attributes and values. ("This is a small thick yellow rectangle.") We now proceed to count differences in pieces.

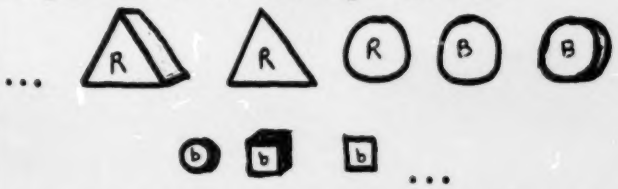
Activity 5 - The teacher takes one piece. Ask the children to find all pieces that are different in exactly one (two, three, four) way(s). Specify the difference.

Activity 6 - The teacher takes two pieces. Count the differences between the pieces.

In each case, four possibilities - color, size, shape and thickness - must be checked. Continue these activities until differences are easily counted. Once this proficiency is obtained, many enjoyable and interesting puzzles are possible.

Activity 7 - Put all the pieces in a row so that any two adjoining pieces differ in just one way.

A portion of the row may look like

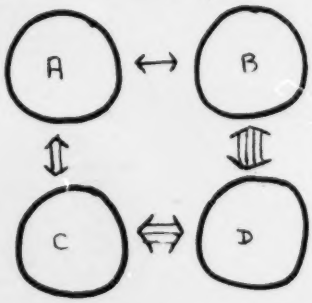


where the differences are, respectively, thickness, shape, color, thickness, size, shape, thickness. This activity can be varied in two directions. The children can be asked to do the same problem with all

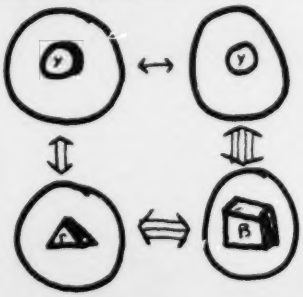
the like colors (or shapes, or sizes, or thicknesses) together. Can any further restrictions be added, like "have all the same shapes together within the colors"? The design of the sequence can also be varied. Can you make a 1 - difference circle, X, or figure 8 (the latter two have one piece of intersection with 4 others branching off it)?

Intermediate Activities - Grids

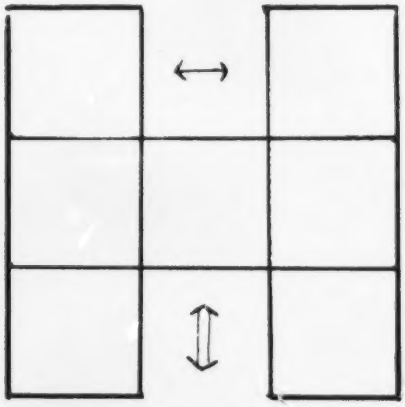
A whole series of activities can now be attempted which all consist of filling in patterns or grids according to specified rules. A useful notation for this is to symbolize with arrows the number of differences required, where ↔ means 1 difference, ⟺ means 2 differences, ⟺ 3 differences and ⟺ 4 differences. Hence



would require the student to find 4 pieces to put in the circles, where A differs from B in one way and C in 2 ways, B differs from A in 1 way and D in 4 ways, etc. A possible solution is

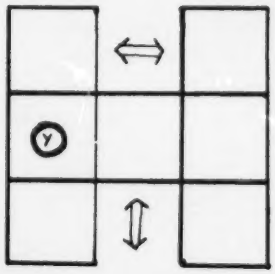


and there are many, many other solutions. Note that with this solution there are 3 differences between A and D and 3 between B and C. Will that always be true? Puzzles can now be generated by determining a grid shape and difference values. This grid

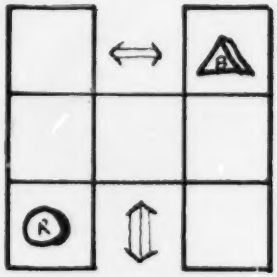


requires finding seven pieces where pieces adjacent horizontally differ in one way and pieces adjacent vertically differ in two ways. Once this has been solved in several ways, fix one or two pieces and see if the rest can be filled in. For example, fill in

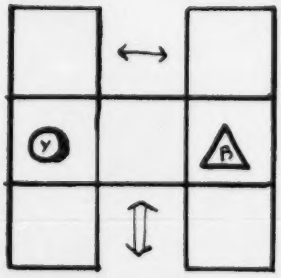
A



B

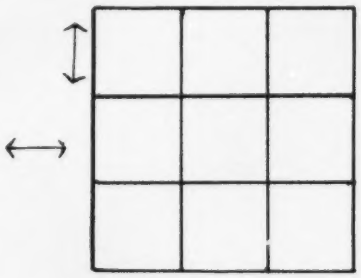


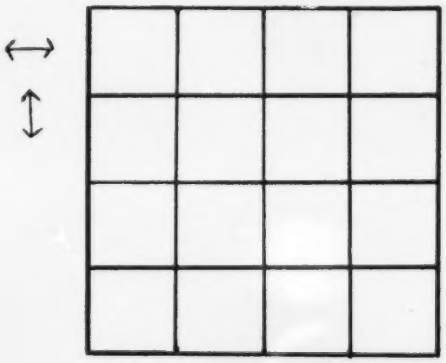
C

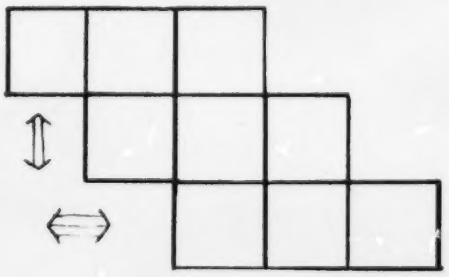


Of these, C cannot be filled in within the requirements shown.

This idea can be extended by varying the grid size and shape, the difference rules, and by predetermining certain pieces. After working a few, the students can make their own set of grids for other students to attempt. Records of solutions can be kept just as we have here. Templates (cardboard with the shapes cut out) may be helpful in getting uniform large/small distinctions. A few other possible grids are:

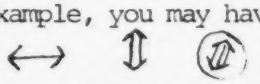




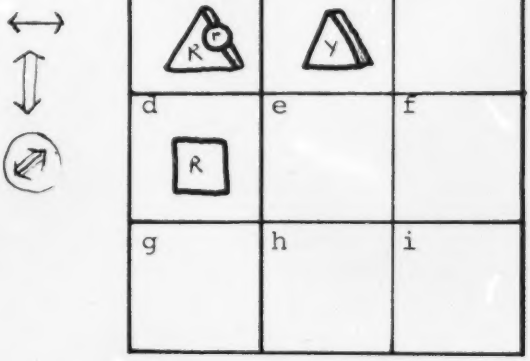


The classroom experts can be challenged to make a 3 - dimensional grid, where you put a second layer of pieces on the grid, with its own difference rule.

For example, you may have



with the circled difference the "stacked" difference. We may start



Note that the first layer in squares a and b differ in color, (1 difference) the first layer in squares a and d differ in thickness and shape (2 differences) and the two layers in square a differ in size, shape and thickness (3 differences). In square b, we need a piece that differs in 3 ways from and in 1 way from .

In square c, we need a piece that differs in 1 way from .

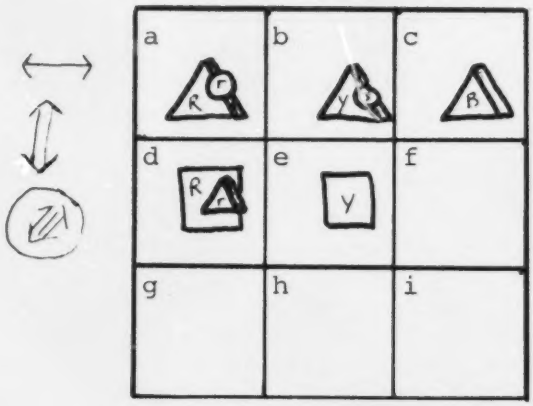
In square d, we need a piece that differs in 3 ways from

and in 2 ways from .

In square e, we need a piece that differs in one way from

and in 2 ways from .

The reader should be able to justify each of these statements from the rules given. A next step could then be

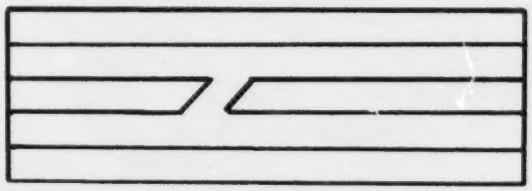


We now need, as top layer in square e, a piece that differs from in 3 ways, from in 2 ways, and from in one way. With this problem, only a systematic, orderly solution is likely to succeed.

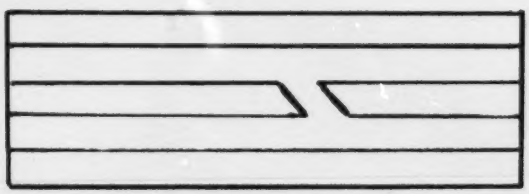
The reader will probably find that for this and succeeding activities to be completely clear, the activities must be actually solved with the materials. Reading this can only give an idea of the problems and their solutions.

Intermediate Activities - Tracks

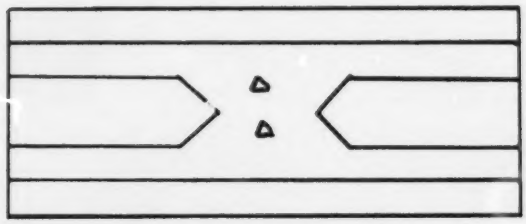
A different kind of activity with the logic materials is sorting the pieces by using "tracks." There are three kinds of tracks, shown here:



Switch Up

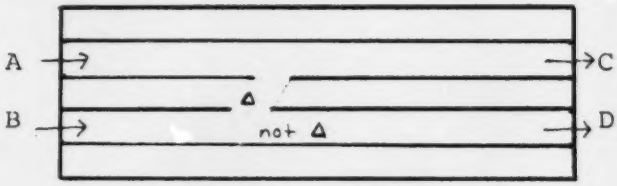


Switch Down

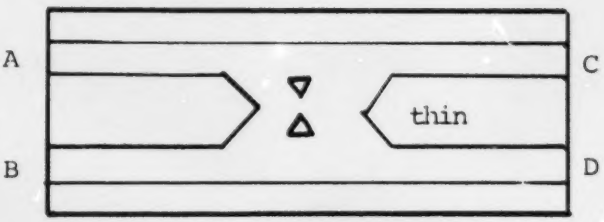


Crossroad

The switch up and switch down are very similar. In the switch up, the lower Y - intersection will be labeled with a value and its negation (red/not red, thick/thin, /not , etc.). Pieces then travel the tracks or road according to the label:



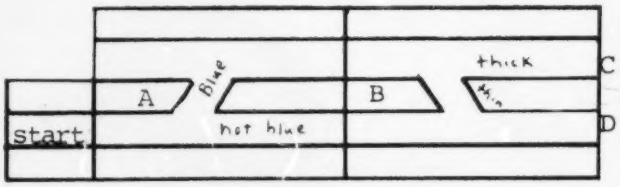
Consider the pieces as "trains" and the directions (labels) as switches that tell the train which track to take. For pieces that enter at B, the lower entry, triangles switch to the top lane and exit at C, while other pieces go straight and exit at D. All pieces, triangles or not, that enter at A go straight through to exit at C. The switch down tracks follow a similar pattern, with pieces entering the top track switching according to the labels, and pieces on the bottom track going straight through. The crossroads have only one label, for example:



Pieces entering either A or B switch top to bottom or bottom to top if they are thin, and go straight through if they are thick. To have a complete set of tracks, you need a single lane "start," about ten tracks of each kind (up, down, cross) and

a set of labels. Note that you need several labels for each value and its negation.

The tracks can now be put together in numerous ways to sort the pieces. For all examples that follow, we will use the 3 x 3 x 2 x 2 set of logic pieces consisting of ○ □ △ in 3 colors, 2 sizes and 2 thicknesses. In this series



switches up at A, goes straight at B and exits at C.

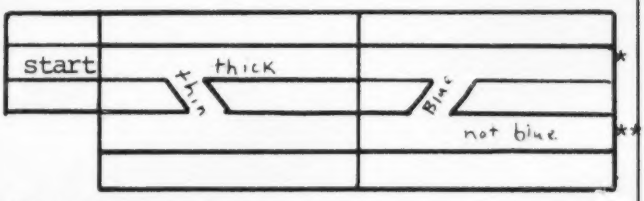
switches up at A, down at B and exits at D. Both

and

go straight at both A and B and exit at D. When the whole set has gone through the tracks, set C consists of pieces that are both blue and thick, while set D has the rest (not blue or thin). Children should have an opportunity to try out various combinations of two or more tracks and attempt to name the outputs in terms of the attributes (use of negatives - not □, not red - is very useful here). Once a free experiment stage has passed, several problems may be raised if they have not yet come up naturally. They are 1) (How) does rearranging the tracks affect outcomes? 2) What combinations don't affect outcomes? 3) Can you name the outcomes from seeing the tracks, without actually sorting the pieces? 4) Can different tracks produce the same outcome? 5) Given a sorting of the pieces, can you find a set of tracks that would produce the sorting?

Examples will be given illustrating each problem:

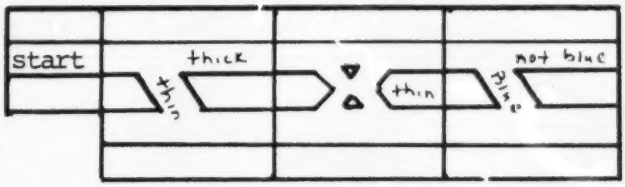
Order of tracks clearly affects outcome. If we reverse the above tracks, we get



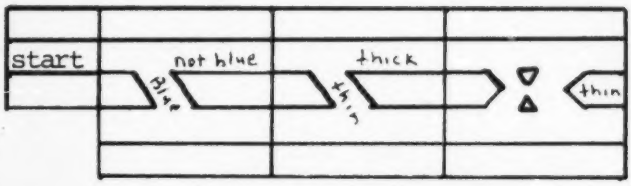
*Thick or blue pieces
**Thin not blue pieces

whereas the reverse order had one set consisting of thick blue pieces. Notice that it is possible to name the sets by following the tracks - thick pieces stay on top, thin switch down, but blue pieces return to the top. Hence the top set consists of pieces that are thick or blue (or both).

The first two tracks in

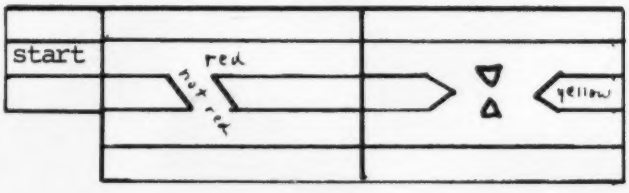


don't affect the outcome; the track simply sorts blue from not blue. However, in this arrangement

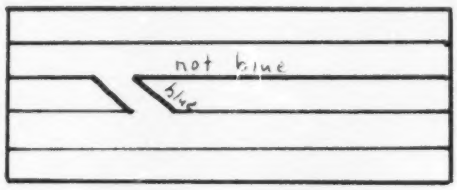


the last two do affect the outcome (only the thick blue pieces come out the bottom road).

It is easy to verify that

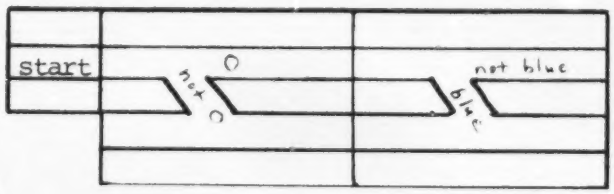


produces the same result as



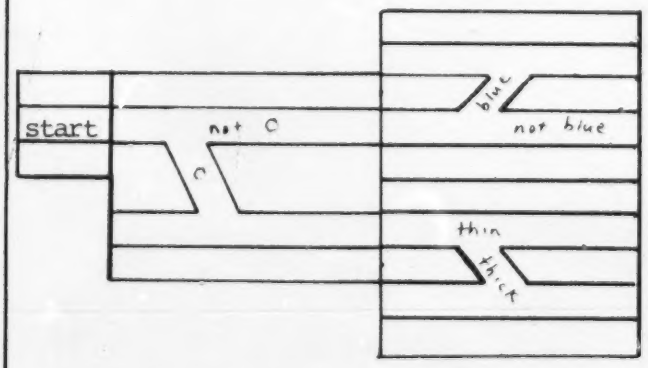
Can you find other such combinations, as well as some more complex equivalent tracks?

The hardest, but most interesting, problem is to specify an outcome and try to find tracks that produce it. For example, try to find a set of tracks that gives the yellow and red circles as one set. This is most easily done if we view the desired set as not blue circles, for then we can sort out circles and eliminate blue:



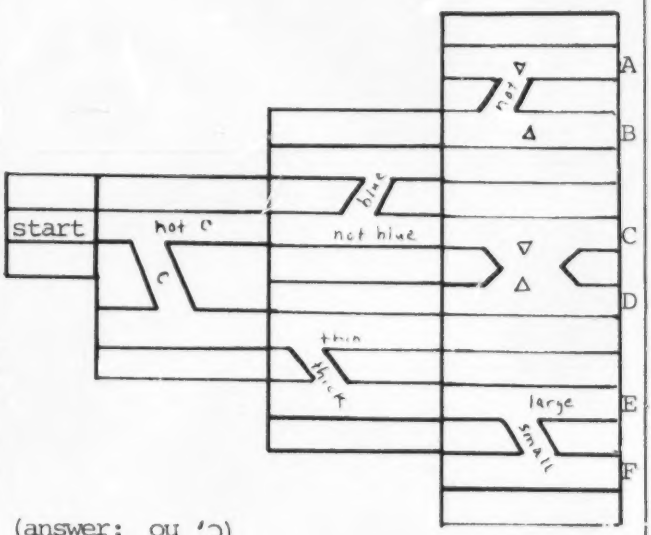
This, of course, was a fairly easy problem. You may work much harder to find a set of tracks that has one set consisting of (circles and not blue pieces), or a set of tracks that has one outcome consisting of (thin squares, thin triangles, thin blue circles, thick yellow circles and thick red circles).

Once these are familiar, more sorting can be done by having an increasing number of roads. For example



will sort the pieces into thin circles; thick circles, blue squares or triangles, and red or yellow squares or triangles.

Where will the thin circles exit in this track, and will they be alone?



(answer: ou 'ɔ)

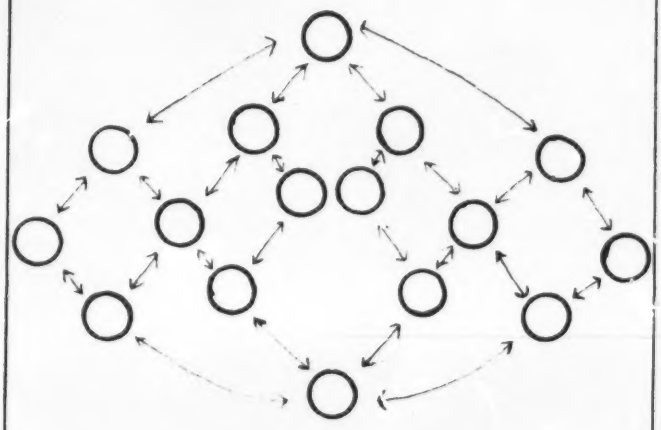
The same kinds of questions as before can now be asked. In particular, children can record their results of tracks they have tried, and have other groups try to find a set of tracks that produce that result. (Note: Remember that in all the track problems, switches must have a dicotomy for labels [e.g. square/not square]. If you labeled a switch square/circle, triangles would have no path to travel. Also, crossroads have only one label.)

Some Advanced Puzzles

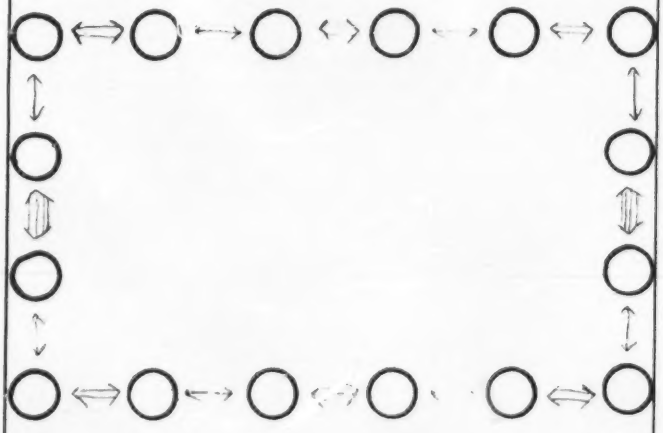
Following are two puzzles whose solutions require 2 x 2 x 2 x 2 sets of logic materials. For example, you may use the people pieces; the logic blocks with 2 shapes, colors, sizes and thicknesses; the logic people with 2 sizes, colors, sexes and positions; or any 2 x 2 x 2 x 2 set described later. It is particularly interesting to solve the following puzzles with several sets of materials and try to relate the solutions; i.e. can we find a correspondence between the sets of logic pieces so that the solutions are the same?

Students should be encouraged to find many solutions to each puzzle.

Puzzle 1 - Fill in the 16 pieces so there is exactly 1 difference between circles connected by ⟷ .



Puzzle 2 - Fill in the 16 pieces so that the number of differences matches the arrows:



Next, can you find a solution so that each 1 - difference ⟷ is the same difference (e.g. all color, or all size, etc.). Now, can you find a solution so that each 2 - difference ⟺ has the same two differences (e.g. size and shape, etc.). Now, make each ⟺ the same three differences.

Some Language Codes

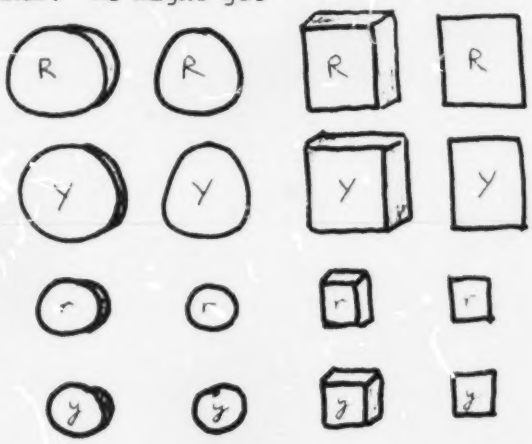
Consider the set of all possible sentences with 4 parts in sequence, where the first part is either "I" or "we." The second part is either "will go" or "went," the third part either "to a party" or "home," and the fourth part either "after school" or "tonight." Suppose each sentence is written on a card. One card in the set would read, e.g., "We will go home after school." Now take a 2 x 2 x 2 x 2 set of logic materials (e.g. R,Y; ○/□; large/small; thick/thin) and match them to the 16 sentences so that you can identify the sentence from the piece and vice versa.

Students might first do this randomly, but if you insist that they use no notes, they can't possibly remember each correspondence. Encourage them to arrange the sentences into an orderly array. This might lead to

I will go to a party tonight	I went to a party tonight	We will go to a party tonight	We went to a party tonight
I will go to a party after school	I went to a party after school	We will go to a party after school	We went to a party after school
I will go home tonight	I went home tonight	We will go home tonight	We went home tonight
I will go home after school	I went home after school	We will go home after school	We went home after school

Note that left half all has "I," left half of each vertical half has "will go," bottom half has "home," top half of each half

has "tonight," etc. It is easy to find inconsistencies in any arrangement until some such pattern emerges. Now ask the students to sort the pieces in a similar manner. We might get



which can be organized in the same way as the sentences. Since both "I" and "O" are are left half, we then correspond "I" with circle. Similarly, red goes with "tonight," thick with "will go," etc. Hence if is chosen, we can use our code to determine it goes with "We will go home after school."

Since there were two values for each attribute, it made no difference how we matched attributes of the pieces with parts of the sentences. Suppose, however, that we now expand our sentence set so that the first part could be "I," "we," "you" or "they" and the second part could be "will go," "go" or "went." (In the classroom you would, of course, expand this one step at a time. For example, you might begin by having 3 choices of subject.) We now need a 4 x 3 x 2 x 2 set of logic pieces (e.g. 4 shapes, 3 colors, 2 sizes, 2 thicknesses), and have much less freedom in assigning attributes to sentence parts. Shape must symbolize the subject, since there are 4 possible subjects and 4 possible shapes. Color must symbolize the verb, since there are three choices of each (last time we had thickness symbolize the verb). These activities are a very concrete way of helping children take a sentence apart and see its components, and how the components may be varied.

Making Logic Materials

Logic materials can be made either to avoid the expense of purchasing materials or to provide a greater variety of materials for the students' work. Following are 4 possibilities for homemade materials; many other possibilities may occur to the reader.

1. Homemade logic blocks: Logic blocks can be made from wood or cardboard. You can make 4 or more shapes (circle, square, triangle, rectangle, hexagon or rhombus [diamond] are standard), three or more colors, two or three sizes and two thicknesses. It is important to have at least 4 attributes, with 3 or more values for at least 2 attributes. Thickness may be hard to vary with tagboard pieces, since two glued together don't really provide a sufficiently apparent difference. Alternatives other than thickness are striped/solid, or even striped/dotted/solid for each color, or have some of the pieces with 1 or 2 holes punched in them. Be sure that you make every possible combination, however. To be sure, count values for each attribute and multiply. You should have that many pieces, all different.

2. Sets of blocks. For a 2 x 2 x 2 x 2 set, make all possible sets using either 0 or 1 block of each color; e.g. (Red, Blue), (Red, Blue, Yellow), (Yellow, Green), (empty). This is the easiest set to make with materials normally in the classroom. Be careful, however, in counting differences; note these examples

   (R, B, Y) $\longleftrightarrow$ (R, B) 1 difference, Y

   (R, B, Y) $\Longleftrightarrow$ (R, B, G) 2 differences! - differ on Y and G

   (R, B) $\Longleftrightarrow$ (Y, G) 4 differences, differ on every color

(empty) $\Longleftrightarrow$ (Y, G) 2 differences, same on R, B

3. Logic houses. Make a 4 x 3 x 2 x 2 set of houses by having 4 possible colors, 1, 2 or 3 windows, 1 or 2 stories and chimney or no chimney. Two houses would be

Note that a different number of windows is 1 difference, regardless of whether they differ by 1 or 2.

4. Logic trees. Make a 4 x 3 x 2 x 2 set of trees from tagboard with 4 colors, 3 shapes, 2 sizes, 2 textures and fruit/no fruit. Texture is provided by gluing coarse sandpaper to the tagboard.

fruit texture and fruit

Rationale:

School mathematics has tended to focus largely on number ideas and, to a much lesser degree, geometry. Logic materials and activities compliment this curriculum nicely, and have several advantages as either a starting point or as a supplimentary activity. Some of these advantages are

1. According to Jean Piaget, children in upper elementary school are beginning to use formal operational thinking. The logic activities provide experiences which can be worked by children in the concrete operations developmental stage, but the activities reward the hypothesis building/testing/modifying used in the formal operations stage.

2. Numbers are rather abstract, complex and go on forever. The logic materials are concrete, simple and finite.

3. Solutions to the logic activities are almost always verifiable by the children; computation normally requires outside (teacher) verification.

4. The logic activities encourage and reward organized problem solving attacks, but also yield to trial and error. Hence anyone can attempt and solve the problems, but they tend to lead students to organized thinking.

5. Since the children can almost understand the problem and recognize a solution, longer problem solving attention spans are encouraged.

Appendix I: Activity Sources

From Creative Publications
P.O. Box 10328
Palo Alto, CA 94303

Attribute Games and Activities
Loop Activity Cards

From Dick Blick Company
P.O. Box 1267
Galesburg, IL 61401

Early Learning and Thinking in Mathematics
Attribute Guide Cards

From Educational Teaching Aids
159 W. Kinzie Street
Chicago, IL 60610

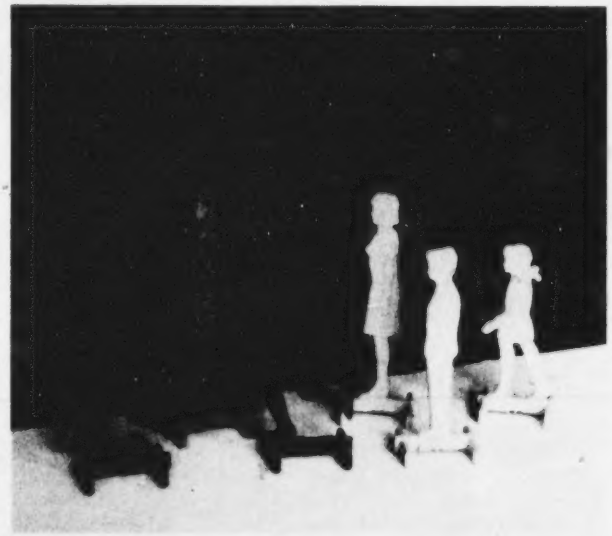
Activity Cards for Attribute Blocks

From Activity Resources Company
P.O. Box 4875
Hayward, CA 94540

Attribute Acrobatics
People Piece Puzzles

Appendix II: Materials' Sources

Logic blocks can be obtained in 4 sizes: pocket (too small for young children), desk top, group and giant (good for teacher demonstration). Some 48 piece sets (4 shape) are available, but most are 60 piece (5 shape) sets. They are available from: Creative Publications, Dick Blick Company or Educational Teaching Aids. People pieces and A - blocks are available from Creative Publications. Dick Blick carries logic people as well as a set of logic tracks. Educational Teaching Aids has a variety of other logic materials. (See Appendix I for complete addresses.)



Introducing the Author

Ron Kutz, a faculty member at the Center for Teaching and Learning, works in math education at the elementary and secondary levels. His main interest is encouraging active math learning, primarily through structuring the students' environment by use of various manipulative materials. The current projects in which he is involved include the construction and use of a one man planetarium, development of transformation geometry materials, writing and testing a computer programming manual for upper elementary and junior high school students. He has just completed a study, supported by the University of North Dakota Bureau of Educational Research and Services, concerning the use of math manipulative materials in North Dakota schools.

INSIGHTS is published eight times during the academic year by the Center for Teaching and Learning, University of North Dakota.

Subscriptions are $3.50 per year payable by check or money order to INSIGHTS, Center for Teaching and Learning, Corwin Hall, University of North Dakota, Grand Forks, ND 58202. Editor - Clara A. Pederson.